Volume 17 DECEMBER 18, 1942 Number 6

National Bureau of Standards
DEC 29 1942

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAMME

FOR THE

LOS ANGELES MEETING

AT

THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES

LOS ANGELES, CALIFORNIA

DECEMBER 29, 1942

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

OFFICERS OF THE SOCIETY FOR 1942

President	P. W. BRIDGMAN	Harvard University
Vice President	A. W. HULL	General Electric Company
Secretary	KARL K. DARROW	Bell Telephone Laboratories (Office at Columbia University)
Treasurer	GEORGE B. PEGRAM	Columbia University
Editor (on leave)	JOHN T. TATE	University of Minnesota
Acting Editor	J. W. BUCHTA	University of Minnesota
Local Secretary for the Pacific Coast	R. T. BIRGE	University of California at Berkeley

COUNCIL

The President, Vice President, Secretary, Treasurer, Managing Editor, the three Past Presidents most recently retired from office, eight elected members and all Past Presidents first elected to the office of President prior to December 1932 constitute the Council which shall have general charge of the affairs of the Society.

Past Presidents now on Council: Henry Crew, W. F. Magie, Ernest Merritt, R. A. Millikan, J. S. Ames, Theodore Lyman, K. T. Compton, W. F. G. Swann, John Zeleny, George B. Pegram and G. W. Stewart.

Elected Members of Council: E. U. Condon, A. J. Dempster, F. G. Brickwedde, H. D. Smyth, J. C. Boyce, A. E. Ruark, L. A. DuBridge and J. S. Foster.

BULLETIN

of the

AMERICAN PHYSICAL SOCIETY

Published seven times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published seven times a year during the months of February, April, June (2 issues), November (2 issues), and December at Prince and Lemon Streets, Lancaster, Pa.

Address correspondence to Prince and Lemon Streets, Lancaster, Pa., or to Secretary Karl K. Darrow, Columbia University, New York, N. Y.

Entered as second class matter, December 23, 1932, at the post office at Lancaster, Pa., under the Act of, August 24, 1912.

Acceptance for mailing at a special rate of postage provided for in the Act of October 3, 1917, embodied in paragraph 4, Section 412, P. L. & R., authorized April 28, 1928.

DECEMBER 18, 1942 Vol. 17, No. 6

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

LOS ANGELES MEETING, DECEMBER 29, 1942

THE 252nd meeting of the American Physical Society will be held at Los Angeles, California, in the Auditorium of the Physics-Biology Building of the University of California at Los Angeles, on Tuesday, December 29, 1942.

Sessions for the presentation of ten-minute contributions will begin at 9:30 A.M. and 1:30 P.M. An invited paper by Professor S. J. Barnett, "Recent Researches in Gyromagnetism," will be given as the concluding feature of the morning session.

GENERAL RULES RELATING TO PAPERS

No paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of the abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

Subsequent meetings. The New York meeting originally announced for December 28–30 will be held on January 22–23, 1943, at Columbia University, New York City. The meeting normally held in February will be omitted. A meeting will take place toward the end of April in a city (certainly not Washington) later to be designated.

R. T. BIRGE,
Local Secretary for the Pacific Coast,
University of California,
Berkeley, California.

PROGRAMME

TUESDAY MORNING AT 9:30 O'CLOCK

Physics Department Auditorium, Physics-Biology Building

1. The Polarization of the Absorption Spectra of Neodymium Ions in Crystals. ROBERT W. KRUEGER, *Douglas Aircraft Company,* AND E. L. KINSEY, *University of California at Los Angeles.*—It has been discovered that many of the sharp electronic lines in the absorption spectrum of crystals containing neodymium ions are polarized. Photographs were taken of the absorption spectra of neodymium ions in crystals of $NdCl_3 \cdot 6H_2O$ and $Nd(BrO_3)_3 \cdot 9H_2O$ cut in various directions with respect to the crystallographic axes, using polarized light. The polarization effect has been successfully explained by the assumption of a perturbing field having the symmetry of the arrangement of the water molecules surrounding the neodymium ion. This field produces a splitting of each unperturbed energy level into a number of component levels equal to the number of irreducible representations of the symmetry group contained in a reducible representation presented by the $2J+1$ unperturbed eigenfunctions corresponding to the unperturbed energy level. When the mixing of unperturbed eigenfunctions to produce a perturbed one is simple, polarization effects become pronounced. Knowing the correct mixing from group theory, one can predict polarizations, using the correct selection rules which are found to be those for forced electric dipole radiation. The splitting and polarization effects observed in at least four groups of lines in the bromate spectrum substantiate the theory very well.

2. On the Heat Transfer from Radiating Gases to Water Tubes of a Boiler. R. M. LANGER AND G. POTAPENKO, *California Institute of Technology.*—The transfer of heat from radiating gases to water tubes of a heat exchanger depends upon the arrangement of tubes, because this arrangement determines the "radiant path length," i.e. the average thickness of gas layer which a tube faces. The theory developed allows one to calculate the radiant path length for any arrangement of tubes. The application of the theory to the case of water tube boilers permits a complete physical analysis of heat exchange in such boilers and leads to the following general formula showing the temperature of gases at any point along the pipes:

$$2xF=\left\{\left(\frac{T^2(0)}{T^2(x)}-1\right)-\tfrac{2}{5}A\left(\frac{T^5(0)}{T^5(x)}-1\right)+\cdots\right\},$$

where x is the distance along the boiler under consideration, F is the fraction of the heat content of the entering gases which is absorbed in the first unit of length. $T(x)$ and $T(0)$ are the gas temperatures at a point x and at $x=0$, respectively. A is the ratio of the convective to the radiative heat transfer coefficient. In the part of the boiler where the radiative heat transfer predominates, A is small and only the first term in the brackets needs to be considered. If ΔT is the temperature rise due to combustion of the fuel gases and if the efficiency of boiler of a length x is $E(x)$ then $T(0)-T(x)=E(x)\Delta T$. The quantities F, A and ΔT can be calculated for any given set of operating conditions and so it is possible to calculate the length of a boiler for any desired efficiency E, and vice versa.

3. The Production of Photons Relative to Ionization by Collision in a Townsend Gap. RONALD GEBALLE, *University of California.*—Measurements were made in a Townsend gap to determine the average number of photons liberated by an electron for each secondary electron it liberates. Gases used included H_2, N_2, A and air. In H_2, this number was found to decrease rapidly with increasing ratio of field strength to gas pressure, in the range from 50 to 150 volts/cm/mm, and at pressures of the order of one millimeter. Determination of the absolute number of photons per electron depends on the unknown efficiency of the photoelectric cell used to count the photons. However, this number is estimated as of order unity. In H_2, the effective radiation has an absorption coefficient of 0.55 ± 0.2 cm^{-1} at a pressure of one millimeter of mercury. This large coefficient indicates that only those photons of rather high energy were counted. There is corroborative evidence that the brass surface of the photoelectric cell had a high work function. Thus only high energy photons would be expected to register. Photoelectric currents in the other gases were too small to be measured with the available apparatus. It thus appears that these gases have absorption coefficients for the effective radiation even higher than that found in H_2.

4. The Magnetic Properties of Iron-Cerium Alloys. J. R. CLARK,* S. T. PAN, AND A. R. KAUFMANN, *Massachusetts Institute of Technology.*—The susceptibility and magnetization of iron-cerium alloys containing 1.07 to 37.8 atomic percent (0.44 to 19.8 weight percent) iron have been measured in fields up to 35,000 gauss and at temperatures from 77°K to 1200°K. The structure of the alloys has been investigated by means of x-ray diffraction patterns recorded at 77°K, 195°K and 300°K. The alloys containing up to about 30 atomic percent iron have a ferromagnetic Curie point at about 275°K; the alloy containing 37.8 atomic percent iron has a ferromagnetic Curie point at about 475°K. Below 275°K the intercept magnetization increases with decreasing temperature and increasing iron content, but there is an abrupt change in the magnetic properties between 150°K and 100°K. At 150°K the alloys are readily saturated; but below 100°K the susceptibility is field-dependent in fields up to 35,000 gauss, the field-dependency being most pronounced in the higher iron-content alloys. The appearance of new lines and a change in the relative intensities of the face-centered cubic lines at 77°K indicate

a structural change in the 1.07 atomic percent iron alloy. This transformation is not apparent in the alloys containing more iron. The Curie points observed are believed to be due to intermediate phases of the Fe-Ce system. The relation between the structural and magnetic transformations at low temperature requires further investigation.

* Now at Stanford University.

5. Theoretical Dependence of Continuous X-Ray Intensity and Polarization upon Several Experimental Parameters. PAUL KIRKPATRICK, *Standford University.*—The Sommerfeld theory of the continuous x-ray spectrum from thin or atomic targets has been put by Weinstock into a form which makes computation feasible. Encouraged by certain agreements between this theory and our experiments, computations have been conducted of the dependence of intensity and polarization upon target atomic number, radiation frequency, bombardment energy and spatial distribution. The computations are still laborious, requiring about six hours of the work of a skilled computer per calculated point. They make possible for the first time the visualization of the principal features of the spectrum. Curves and space models are used to display the functional relations disclosed.

6. Direct and Fluorescence Excitation of the L_{III} Level in Thick Targets of Thorium. BURR G. BURBANK, *Stanford University. (Introduced by Paul Kirkpatrick.)*—X-rays from an oil-cooled thorium target were analyzed by a Bragg spectrometer, the intensities at the peak of the $L\alpha$ line and in its continuous background at both sides being measured. The line intensity was partly produced by direct cathode electron ionization of the thorium atoms and partly by ionization produced by absorption of the thorium continuous spectrum. To determine the ratio of these components auxiliary measurements were performed in which the thorium target was covered by a foil of palladium thick enough to prevent direct ionization of the thorium and to provide a palladium continuous spectrum sufficiently intense to excite a measurable intensity of Th $L\alpha$ by photoelectric ionization. From measurement of this purely indirect line excitation the indirect component with pure thorium targets was computed by a procedure taking account of the relative continuous background intensities in the two experiments. The ratio of the number of $L\alpha$ line quanta produced by direct electron collision to the number produced by fluorescence for normally emergent x-rays from a thick thorium target was found to be 2.8 for 40-kv electrons. Determinations were made in the range from 40 to 100 kv.

7. Inelastic Scattering of Slow Neutrons. ROBERT WEINSTOCK, *Stanford University.*—The first-order (single phonon emission or absorption) inelastic scattering cross section for neutrons by polycrystals has been calculated. The Born approximation and the Fermi (δ-function) interaction between slow neutrons and bound nuclei are employed. In the preliminary work, attention is limited to spin-free nuclei, and both isotopic disorder and magnetic interaction are neglected. The Debye approximation of a constant sound velocity is used. The ratio of the probability of a first-order process to zero order (elastic) is found to be roughly of the order of neutron mass divided by scattering nucleus mass. At temperatures high compared with the Debye temperature of the scatterer, however, the inelastic cross section may become larger than this ratio indicates. Computations carried out for Fe scattering room temperature neutrons show a rise from three percent at 151°K to 27 percent at 1000°K for the ratio of (first order) inelastic to elastic scattering cross section. The sum of these cross sections, however, varies only slightly over this temperature range. Future work will take into account both isotopic disorder and magnetic interaction.

8. Dimensional Characteristics of the Large Scale Condensations of Matter in the Universe. F. ZWICKY, *California Institute of Technology.*—It is one of the most fundamental facts of observation that the large scale distribution of matter is very far from uniform. Clusters of nebulae, nebulae and stars the dimensions of which are of the order 10^{25} cm, 10^{22} cm and 10^{11} cm, respectively, represent the most conspicuous condensations on a cosmic scale. A complete theory of the structures of these condensations is lacking because it involves the statistical mechanics of cooperative gravitational systems, a discipline which has not yet been developed. General considerations coupled with dimensional analysis show that the "structural length" α for clusters of nebulae and for nebulae must be of the order $k(\bar{\epsilon}_k/\Gamma\rho_0)^{\frac{1}{2}}$ where $\bar{\epsilon}_k$ is the average kinetic energy per unit mass of all the matter in the universe, ρ_0 its average density, Γ the universal gravitational constant and k a dimensionless constant. For individual clusters of matter which are in stationary equilibrium k assumes the value $(12\pi)^{-\frac{1}{2}}$ if ρ_0 denotes the central density. These conclusions are checked through a comparison with the data obtained on the three large clusters of nebulae in Coma, in Perseus and in Hydra.

9. Static Charges Produced on Moving Rubber-Tired Vehicles. S. S. MACKEOWN AND VICTOR WOUK, *California Institute of Technology.*—The current flowing from an automobile whose rear wheels were turning on a dynamotor was measured. These results show that the total current generated is proportional to speed, independent of load or tire pressure. Measurements made when the tires were made semi-conducting and with a series resistance suggest a simple equivalent electric circuit that is consistent with the experimental results. Approximate values of the constants of this equivalent circuit were obtained. Constant currents as high as 4 microamperes were obtained at a speed corresponding to 40 miles per hour. These results were checked by road tests. The tires are sufficiently conducting to discharge the automobile in a short time after the car is stopped.

Invited Paper

Recent Researches in Gyromagnetism

S. J. BARNETT, *University of California at Los Angeles and California Institute of Technology*

TUESDAY AFTERNOON AT 1:30 O'CLOCK

Physics Department Auditorium, Physics-Biology Building

10. Preliminary Energy Distribution Curve of Cosmic Rays. L. KATZ, R. V. ADAMS, JR. AND W. E. DEEDS, *California Institute of Technology.* (*Introduced by C. D. Anderson.*)—Several test runs have been made with the twenty-four inch, vertical cloud chamber at a field strength of approximately 5000 gauss. A preliminary energy distribution curve has been made, on the basis of measurements of 107 tracks, with energies ranging from 100 Mev to 31,000 Mev. Altogether, there were 54 tracks of negative particles, 51 of positive particles, and 2 of doubtful sign. In the region above 5000 Mev there were 5 negatives, 9 positives, and 2 doubtful cases. The tentative curve shows several secondary maxima, including one at 1700 Mev, which may or may not be due to statistical variation.

11. The Origin of Cosmic Rays. ROBERT A. MILLIKAN, H. VICTOR NEHER AND WILLIAM H. PICKERING, *California Institute of Technology.*—The authors had predicted that since their hypothetical silicon-annihilation rays should have enough energy (13.2 bev) to get through the earth's magnetic field at the equator in Peru, though not in India, there should be found both at sea level and at all altitudes in the Americas a very long plateau of uniform, vertical cosmic-ray intensities extending north from Peru clear up about to the magnetic latitude of Victoria, Mexico (32.8° N Mag.). There the strong band due to the annihilation of the oxygen atom (computed energy 7.5 billion electron volts) should first begin to be able to break vertically through the earth's magnetic field. This prediction and others deducible from the hypothesis were experimentally tested in Mexico and the United States in December, 1940, with no results as yet found anywhere at variance with the atom-annihilation hypothesis.

12. An Improved Cosmic-Ray Radio Sonde. WILLIAM H. PICKERING, *California Institute of Technology.*—A description will be given of the cosmic-ray radio sonde used for the measurements described in the preceding paper (No. 11). The chief difference between this and the preceding instrument lies in the method used to scale down the counts. This is now done at the receiving station. The transmitted pulses are made sufficiently short to avoid any loss of efficiency at high counting rates.

13. Mesotron Mass and Heavy Tracks on Mt. Evans. CARL E. NIELSEN AND WILSON M. POWELL, *University of California.*—A cloud chamber in a 2500 oersted field was so operated that diffuse tracks permitting ionization measurement by droplet count were photographed. A few slow mesotrons with ionization and curvature suitable for mass determination were observed in the approximately 7000 photographs taken at 14,100 ft. and the 1500 at 12,700 ft. Preliminary measurement of two of the best tracks indicates a mass of about 200 electron masses; the mass is determinable from each track to within ±15 percent. There were observed also many heavily ionized tracks made by protons or heavier particles—several such appear in each hundred photographs. A count is being made of the relative frequency of these heavy tracks at the two elevations; the decrease with elevation is not conspicuous.

14. Collision Electrons Accompanying Mesotrons in Lead at 10,000 Feet. WAYNE E. HAZEN, *University of California.* (*Introduced by R. B. Brode.*)—A cylindrical cloud chamber (30 by 30 cm) containing eight 0.6 cm lead plates was expanded at random. Two thousand of the photographs have been studied for the production of knock-on electrons in the lead. In these photographs 4540 particles traversed at least three plates without multiplication but only 4570 traversals were classified as suitable for the observation of knock-on electrons. Since 340 electrons were observed, of which only 2.5 percent passed through another 0.6 cm of lead, the plates were thick enough to establish equilibrium. Ten percent of the knock-on electrons were noticeably scattered in the gas and therefore had energies less than 10^5 ev. There were two cases of small showers accompanying mesotrons out of the lead, one of three and the other of four particles. From the above data the probability that a collision electron accompanies a mesotron in lead is 7.5±0.5 percent. Seren[1] found 9.7 percent for the probability that a collision electron with $E>4\times10^6$ ev accompanies a mesotron in lead at sea level. The difference is probably a consequence of the higher mean energy for mesotrons at sea level.

[1] L. Seren, Phys. Rev. **62**, 204 (1942).

15. Optical Constants of Electron Microscopes. L. MARTON AND R. G. E. HUTTER, *Stanford University.*—In electron microscopical work it has been previously assumed that the field of the objective lens which extends beyond the specimen into the region between it and the condenser lens is not strong enough to exert an appreciable converging effect on the illuminating beam of electrons. Recent calculations of Glaser[1] and Dosse[2] show that if the object is placed at a distance from the lens where the spherical aberration becomes a minimum, the converging effect is far from negligible. Taking into account the necessary corrections for such an extended objective field and with a minimum of assumptions, several optical constants

of the electron microscope are recalculated. For the new values thus obtained, the resolution of the instrument is calculated and the role of the limiting factors discussed.

[1] Zeits. f. Physik **117**, 285 (1941).
[2] Zeits. f. Physik **117**, 316 (1941).

16. The Influence Function for a Cubic Lattice. H. BATEMAN, *California Institute of Technology.*—In 1912 Born and Kármán studied the periodic solutions of a differential difference equation analogous to the wave equation for a homogeneous isotropic medium. An expression is now found for the disturbance produced when one member of an elastic lattice system is given an initial displacement or velocity.

17. Theory of Elastic Oscillations in Plates and Shells. PAUL S. EPSTEIN, *California Institute of Technology.*—The assumptions forming the foundation of the classical theory of plates and shells are open to the objection of being arbitrary. A new theory meeting this objection is offered and carried through for the following cases: (1) with respect to terms of zero order in the thickness of the shell (h), for shells of any shape; (2) with respect to terms of second order in h, for circularly cylindric shells (including, as a special case, plane parallel plates). The zero-order terms turn out to be identical with those resulting from the classical theory, while the second-order terms are different. The new theory gives a satisfactory account of torsional oscillations which cause difficulties in the classical theory.

SUPPLEMENTARY PROGRAMME

18. Continuous Radiation in Prismatic X-Ray Spectra. PAUL KIRKPATRICK, *Stanford University.*—In determining e/m by x-ray reflection and refraction[1] Stauss observed in his prismatic x-ray spectrograms unexpected refraction between the $K\alpha$ lines of Mo and the undeviated beam. He was inclined to attribute this radiation to imperfection of the surfaces of his quartz prism. Pardue[2] while investigating the dispersion of x-rays in calcite noticed the same effect and attributed it to refracted continuous spectrum radiation of wave-length less than that of the molybdenum lines. The band possessed a sharp edge on the *long wave* side which he thought might be a result of a deposit of tungsten on the molybdenum target. It is shown in the present work, using a glass prism, that the band is indeed continuous radiation since it responds appropriately to voltage and filtration variations. The sharp edge on the long wave side is found to be a photographic effect caused by the K discontinuity of the silver in the film.

[1] H. E. Stauss, Phys. Rev. **36**, 1101 (1930).
[2] L. A. Pardue, Phys. Rev. **38**, 1808 (1931).

Author Index to Abstracts of the Los Angeles Meeting

Adams, R. V., Jr.—see Katz, L.
Bateman, H.—No. 16
Burbank, Burr G.—No. 6
Clark, J. R., S. T. Pan, and A. R. Kaufman—No. 4
Deeds, W. E.—see Katz, L.
Epstein, Paul S.—No. 17
Geballe, Ronald—No. 3
Hazen, Wayne E.—No. 14
Hutter, R. G. E.—see Marton, L.
Katz, L., R. V. Adams, Jr., and W. E. Deeds—No. 10
Kaufman, A. R.—see Clark, J. R.
Kinsey, E. L.—see Krueger, Robert W.
Kirkpatrick, Paul—Nos. 5 and 18
Krueger, Robert W. and E. L. Kinsey—No. 1
Langer, R. M. and G. Potapenko—No. 2
MacKeown, S. S. and Victor Wouk—No. 9
Marton, L. and R. G. E. Hutter—No. 15
Millikan, Robert A., H. Victor Neher, and William H. Pickering—No. 11
Neher, H. Victor—see Millikan, Robert A.
Nielsen, Carl E. and Wilson M. Powell—No. 13
Pan, S. T.—see Clark, J. R.
Pickering, William H.—No. 12
—— see Millikan, Robert A.
Potapenko, G.—see R. M. Langer
Powell, Wilson M.—see Nielsen, Carl E.
Weinstock, Robert—No. 7
Wouk, Victor—see MacKeown, S. S.
Zwicky, F.—No. 8

Noted on ch. Apr. 15-43

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

WASHINGTON

ADDRESS REPLY TO
NATIONAL BUREAU OF STANDARDS
SAJ:NJH

April 9, 1943

IN YOUR REPLY
REFER TO FILE
0-6:PGU

Secretary, American Physical Society,
Columbia University,
New York, N. Y.

Subject: Publications

Dear Sir:

In checking our volume of your Bulletin for the bindery we find that we do not have Vol.17, no.7, 1942. We shall appreciate it very much if you will send us a copy as soon as possible.

Please address reply:

National Bureau of Standards Library,
Washington, D. C.

Respectfully,

NATIONAL BUREAU OF STANDARDS.

This was never published because of the cancellation, or rather the postponement, of the meeting which was to be held at New York in December 1942. When the postponed meeting was finally announced the Bulletin was marked "Vol. 18, #1".

K. K. Darrow
Secretary